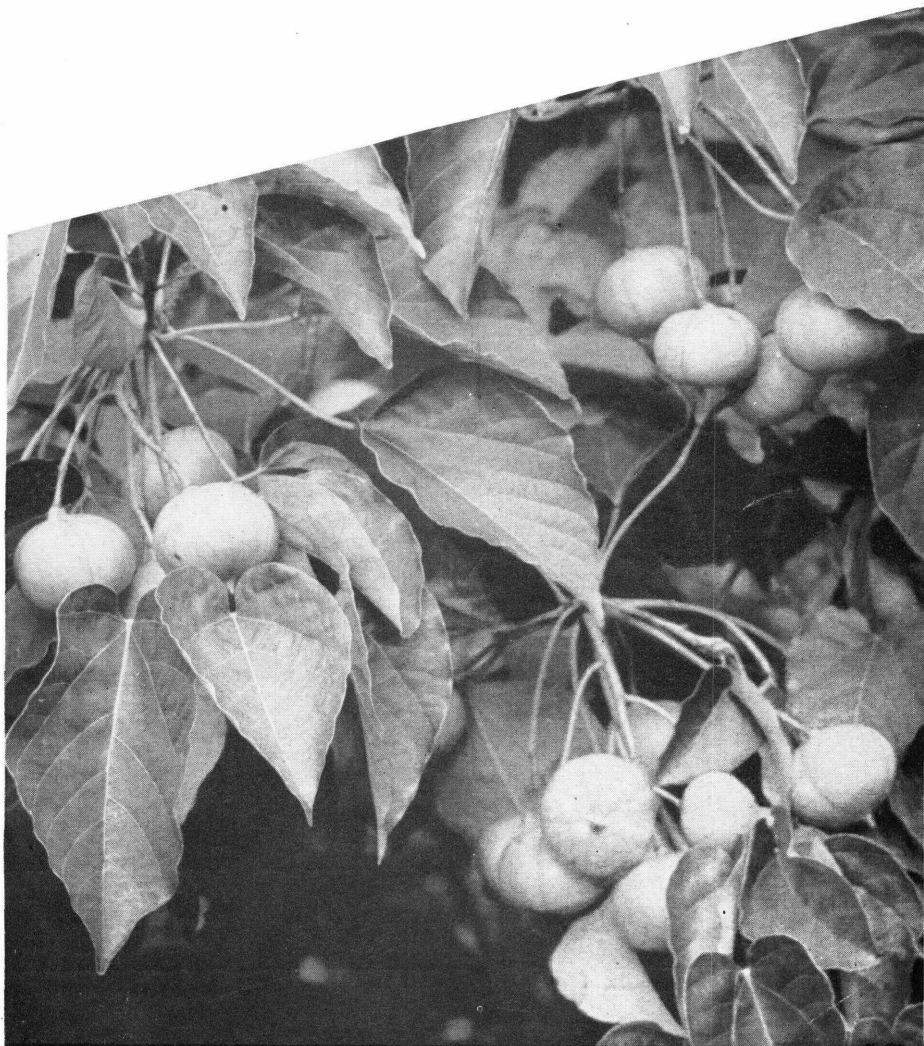


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TUNG PRODUCTION



FARMERS' BULLETIN No. 2031
U. S. DEPARTMENT OF AGRICULTURE

TUNG OIL is one of the best quick-drying oils for use in manufacturing. The three principal users of tung oil are the paint and varnish, linoleum and oilcloth, and printing-ink industries. Tung is an essential commodity in the production of military goods, being especially useful as a moistureproof coating for various types of containers and as insulation for wires.

The tung tree (*Aleurites fordii*) is a comparatively recent introduction to the United States from China. Although domestic production has increased rapidly in the past few years, orchards in this country are at present providing only 20 percent of the total requirements.

A long-season, hot-weather tree that is exacting in climatic requirements, tung does best where both the days and nights are warm. It needs at least 45 inches of rainfall rather evenly distributed throughout the year. Low-priced land and labor are necessary for a successful enterprise. For these reasons tung culture in the United States is limited to a narrow belt in the South, mostly along the Gulf of Mexico.

The trees usually begin to bear fruit about the third year from seed and are in commercial production by the sixth or seventh year. The average life of a tung tree in the United States is at least 30 years.

A farmer already living on the land can start a tung orchard with a very small cash outlay. Tung growing fits well into diversified farming, and equipment requirements are simple for a few trees, enlarging according to the extent of the enterprise.

TUNG PRODUCTION

By GEORGE F. POTTER, *principal physiologist*, and HARLEY L. CRANE, *principal horticulturist, Division of Fruit and Nut Crops and Diseases, Bureau of Plant Industry, Soils, and Agricultural Engineering, Agricultural Research Administration*¹

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PRODUCTION IN THE UNITED STATES, IMPORTS, AND USE

THE TUNG TREE produces one of the best quick-drying oils for use in manufacturing. Planting in the United States is limited to a belt about 100 miles wide that extends from eastern Texas along the Gulf of Mexico to the Atlantic Ocean. This area includes the northern third of Florida and the southern third of Georgia. (See fig. 1.)

A comparatively recent introduction to the United States, the tung tree is native to central and western China, where seedlings have been planted for thousands of years.

Tung was introduced into the United States in 1905 by Consul General L. S. Wilcox, who sent seed to the State Department. This seed was turned over to the Division of Foreign Seed and Plant Introduction (now Plant Exploration and Introduction) of the United States Department of Agriculture.

The first successful commercial orchard was planted in 1924 in Florida, and the first mill for expressing the oil from the nuts was placed in operation near Gainesville, Fla., in 1928. A few large-scale plantings were made in the late 1920's and early 1930's, and extensive plantings were made in the late 1930's.

Increase in production of tung fruit (nuts) in the United States from 1939 through 1949 was rapid, with a total of a little more than 1,000 tons being produced in 1939, and 87,900 tons in 1949, yielding about 26,000,000 pounds of oil. Planting continues and most of the orchards have not yet attained full production. Data on production by States are given in table 1.

¹ Several present and former members of the staff of Tung Investigations of the Division of Fruit and Nut Crops and Diseases have contributed subject matter for this bulletin, as follows: R. T. Brown, site requirements; M. Drosdoff, soils; F. S. Lagasse, cultural practices; J. R. Large, diseases; S. Merrill, propagation; M. S. Neff, establishing the orchard; and B. G. Sitton, fertilization.

TABLE 1.—*Production of whole air-dry tung fruits in the 5 Tung-Belt States, 1939-49, inclusive*¹

State	Production of tung fruits in—										
	1939	1940	1941	1942	1943	1944	1945	1946	1947	1948	1949
Alabama	Tons 20	Tons 200	Tons 350	Tons 500	Tons 100	Tons 700	Tons 1,140	Tons 1,600	Tons 800	Tons 900	Tons 1,900
Florida	550	4,700	2,250	3,700	700	7,000	8,400	15,000	11,000	17,500	16,200
Georgia	15	1,200	650	950	200	800	1,100	1,800	1,900	800	1,000
Louisiana ²	150	1,200	1,800	4,000	3,260	7,550	10,750	15,200	15,500	14,000	25,200
Mississippi	425	3,700	3,700	7,200	1,940	10,630	15,690	23,800	25,000	25,300	43,600
Total	3 1,160	11,000	8,750	16,350	3 6,200	26,680	37,080	57,400	53,200	58,500	87,900

¹ Data obtained from the Crop Reporting Service, Division of Fruit and Vegetable Statistics, Bureau of Agricultural Economics, U. S. Department of Agriculture.

² Includes small quantities from Texas.

³ Frost damage reduced totals for 1939 and 1943.

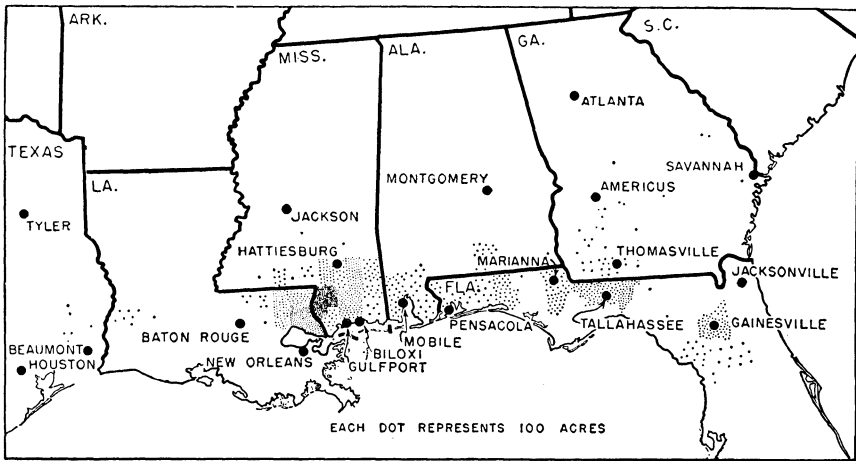


Figure 1.—The Tung Belt of the United States is about 100 miles wide and extends from eastern Texas along the Gulf of Mexico to the Atlantic Ocean. Dots on the map indicate present acreages.

Individual and isolated groups of tung trees have been reported growing satisfactorily, some for a number of years, in certain localities north of the Tung Belt, but the trees cannot be grown commercially in those areas.

Warm winters, inadequate rainfall, and the high cost of land, irrigation, and labor practically exclude the Pacific coast and the Southwest as regions of tung production in the United States.

The tung tree is very exacting in its climatic requirements and also in its soil requirements. It has been relatively free from insects and diseases in the United States, only a few of these having caused losses serious enough to justify control measures.

At present most of the tung in the United States is produced on large, specialized plantations, but tung production should be part of a diversified farming operation. It fits well into such a pattern, requiring relatively little labor during the time of year that most other crops need attention and providing productive employment in winter, when the farmer often has little else to do. In all cases some diversification is advisable (discussed more fully on p. 10).

The nonresident owner who starts a farm solely for tung production is likely to incur a large investment per acre of orchard and high overhead costs, but a farmer already living on the land can start a tung orchard with a very small cash outlay. The amount and kinds of machinery already on the farm will usually do for a small orchard. Large acreages require extensive use of several kinds of modern farm implements.

An unfortunate feature of the tung industry is that the price of tung oil tends to fluctuate widely. However, price supports were placed in effect on tung nuts in 1949 by the United States Department of Agriculture.

Those who embark upon a tung enterprise should aim at attaining high average yields, $1\frac{1}{2}$ to 2 tons of fruit per acre, with high oil con-

tent. For example, at 25 cents per pound for oil, a grower would receive \$62.50 per ton of fruit delivered (300 pounds of oil) after deduction of the average 1949 milling costs of \$12.50 per ton. An increase of only 2.5 percent in oil content of the fruit would bring the grower \$75.00 for each ton of fruit under the price-support program.

Future prices will depend upon such varied items as price supports, amount and price of oil from China and South American countries, and demand. At present, tung orchards in the United States produce only 20 percent of the requirements for this country.

Tung-oil imports into the United States began about 1870 but did not reach an appreciable volume until the early 1900's. Between 1912 and 1919, the total imports averaged a little more than 43,000,000 pounds a year. Between 1920 and 1937, imports increased steadily until more than 174,000,000 pounds, an all-time high, were shipped to this country in 1937. After that, because of the Sino-Japanese War and World War II, imports declined until only 67,893 pounds were imported in 1943.

At the end of World War II in 1945, China was badly disorganized, without adequate transportation equipment, and in the midst of a civil war. Nevertheless, because of the need for dollar exchange, the Chinese Nationalist Government made tung oil available for export. Shipments to the United States increased rapidly to prewar levels. Total imports for 1948 and 1949 were, respectively, 131,500,000 and 65,000,000 pounds, all of which originated in China except 1,500,000 pounds from Brazil in 1948 and 16,500,000 pounds from Argentina in 1949. Prospects for future importations from China are extremely uncertain.

Factory consumption in the United States closely paralleled imports during the period 1912 through 1937. Beginning in 1938 consumption declined somewhat because of the slump in imports. During the war, imports practically ceased, but stocks of imported oil on hand and of domestic oil were sufficient to keep consumption at a level of 10,109,000 pounds in 1944. Beginning in 1945, use of tung oil increased rapidly and in 1948 the prewar consumption level of 120,278,000 pounds was again attained.

Three principal users of tung oil are the paint and varnish, linoleum and oilcloth, and printing-ink industries. These consumers use the oil to produce rapid-drying paints and varnishes, aircraft finishes, moistureproof coatings for cloth and other fibrous or porous materials, and inks. Tung-oil products are used to coat containers for food, beverages, and medicines. Large quantities are used as insulation for wire and other metallic surfaces such as those used in radio, radar, telephone, and telegraph instruments. Tung oil is also used in the production of synthetic resins, artificial leather, felt-base floor coverings, wallboard, and paper products. In addition, it is used in lithographic printing and in the manufacture of certain types of gaskets, brake linings, lubricants and greases, and in cleaning and polishing compounds.²

² Further details on industrial uses of tung oil may be obtained from the U. S. Department of Commerce publication *Tung Oil, A New American Industry*, Department of Commerce publication, *Tung Oil, A New American Industry*, Printing Office, Washington 25, D. C., for 25 cents.

THE TUNG TREE

In early spring the tung tree³ is highly ornamental, blossoming with clusters of whitish, generally purple- (mallow-) throated but sometimes yellow-throated flowers. Broad, handsome, dark-green, heart-shaped leaves appear just after the bloom. The shape of the leaves has given the tree its name. Tung is a Chinese word for heart.

The flower clusters, which are borne at the terminals of shoots produced the previous season, may consist wholly of staminate (male) flowers, or, in rare instances, of pistillate (female) flowers only. Usually, however, one or more pistillate flowers are surrounded by a number of staminate flowers. New shoot growth is made from lateral growing points located within the terminal buds of the shoots.

The tree grows rapidly to a height of 40 feet or more and when mature has a top spread approximately the same as the height.

Tung usually begins to bear fruit about the third year from seed, and should be in substantial commercial production by the sixth or seventh year. Some of the first orchards planted in the United States are still bearing satisfactorily. The average life of a tung tree in this country should be at least 30 years.

The fruits of the tung tree are about the size of small apples. They are generally spheroid but may be shaped like a top, a tomato, or a pear. The tung fruits mature and drop to the ground in late September to early November. At that time they may contain as much as 60 percent moisture by weight. The fruits are dried before oil is expressed. An average fruit contains 4 or 5 seeds, but the number may be from 1 to 15. The seeds vary in size from $\frac{3}{4}$ to $1\frac{1}{4}$ inches long and from $\frac{1}{2}$ to 1 inch wide. Generally the larger the number of seeds per fruit, the smaller the size of the seeds. The seed is composed of a hard outer shell and a kernel that is largely oil-bearing tissue, with a small embryo. The oil is expressed from the kernels.

CLIMATE

Tung is even more exacting than pecans or cotton with respect to heat requirements. Production is best where both the days and nights are uniformly warm. Much variation in day and night temperatures will produce less tree growth and smaller fruits.

The tung tree requires at least 45 inches of rainfall rather evenly distributed through the year. This amount and distribution of water is required because of large leaf area, warm temperatures necessary for culture, and the nature of soils that are suitable for tung orchards. The chilling requirement of dormant tung trees during the winter is from 350 to 400 hours of temperatures at 45° Fahrenheit or lower. If

³Tung, botanically *Aleurites fordii*, is a member of the Spurge family and is the most valuable species of the genus. It is native to central and western China, where it is widely grown under primitive methods of culture. Tung yields most of the commercial "tung oil," although a related species, the mu-tree (*A. montana*), yields an oil so similar to that of tung that the two are perfectly compatible. In southern China the mu-tree is the prevailing commercial species. The mu-tree might be grown in areas of this country where there are very mild winter temperatures. Three other related species, the Japan wood-oil tree (*A. cordata*), the candlenut, or lumbang, tree (*A. moluccana*), and the soft lumbang tree (*A. trisperma*) yield inferior oil. They cannot be grown commercially in the United States.

this cold requirement is not met the trees generally flower over a prolonged period, start late, irregular growth, and tend to produce suckers.

The cold resistance of the tung tree depends largely upon its vigor and its degree of dormancy when minimum temperatures occur. Vigorous but not succulent growth is most cold-resistant. Thoroughly dormant, well-nourished trees have withstood temperatures down to 8° F. and even lower without apparent injury. Under the same conditions a poorly nourished tree or an exceedingly succulent one might be partly killed back if not entirely destroyed.

The rate at which the temperature falls and the weather preceding the minimum temperature are also important factors. A gradual drop in temperature following a period of rather cool weather will cause much less injury than a rapid drop to the same low temperature following a period of warm weather. Trees that have been stimulated to activity by unseasonably warm weather are extremely sensitive to cold and have been killed to the ground by temperatures of 23° to 28° F. occurring just after active growth had started in the spring.

SELECTING AND PREPARING LAND

SITE SELECTION

Because tung trees start growth and blossom early in the spring (February or March), the risk of freezing injury is greatly reduced if orchards are planted on hilltops and slopes (fig. 2). On a still night, cold air will drain from the hilltops down the slopes and settle in the valleys and bottom lands. "Frost pockets" are to be avoided when planting. Frost pockets are depressions with no outlets through which cold air can drain to lower ground. A dense forest at the bottom of a slope may create a frost pocket by impeding the passage of cold air.



Figure 2.—These tung trees, contour-planted on high, rolling land, will escape frost injury at a time when the crop would be destroyed in orchards in lowlands or flat fields.

The elevation at which tung may be planted above a valley floor depends upon the width of the valley and the size of the area from which cold air drains into it. The wider the valley and the smaller the area draining into it, the lower the elevation at which plantings may be made. Good air drainage is of major importance in the northern limits of tung culture, as in central and northern Louisiana and Mississippi.

It is wise to select a site in an area where previous tung plantings have led to the establishment of a mill at which the crop can be marketed and processed, or in an area where new plantings will justify the establishment of a mill. Distance required to travel for supplies of fertilizer and equipment should also be considered as well as the availability of an adequate labor supply. Good roads to the site are desirable because the crop is generally hauled to market in winter, when unimproved roads are likely to be at their worst.

The price of land must also be considered in the selection of an orchard site. Tung makes its best growth on virgin land. However, if it is not feasible to use cut-over land, the prospective grower might well purchase old, cleared farm land. Numerous instances have been noted of successful orchards being produced on "worn-out" farms. For good growth and production on old land the soil must be satisfactory from the standpoint of drainage, depth, and texture; green-manure crops must be turned under; weeds must be controlled by intensive cultivation; and proper fertilizers must be used.

SOIL SELECTION

A tung-growing enterprise is a long-term investment, and therefore it is quite important that the proper soil be selected for an orchard. It is almost if not wholly impossible to correct an error in soil selection after the orchard has become established. That a soil is unsuited for tung production may not become apparent to the inexperienced grower for several years after the trees are planted. A shallow, poorly drained soil, for example, may produce satisfactory tree growth for several years, especially if the seasons are favorable; but as the orchard comes to maturity, growth and production of the trees will be seriously reduced.⁴

Tung trees require soils that are deep, well drained, and aerated and that have a high moisture-holding capacity. The soil should be easily penetrated by plant roots, contain an adequate nutrient level, and have a satisfactory degree of acidity. It is possible to correct low natural fertility by the addition of fertilizers and to correct excessive acidity by the addition of dolomitic lime.

A soil is made up of various layers (horizons), each of variable depth. The total depth of the horizons extends to several feet. It is necessary to know the properties of the lower layers in order to tell if the soils are good for crop production, especially for a tree crop like tung.⁵ Widely different soils may have similar surface layers.

⁴ For a detailed discussion of soils, see U. S. Department of Agriculture Circular 840, *Suitability of Various Soils for Tung Production*. For sale by the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., for 10 cents.

⁵ Soil maps of certain areas and counties are available from most State agricultural experiment stations or from the Bureau of Plant Industry, Soils, and Agricultural Engineering, Plant Industry Station, Beltsville, Md.

The lower layers have a great effect on drainage. Good drainage is one of the most important considerations in choosing a soil for growing tung trees. Many soils are not sufficiently well drained. Either the permanent water table is too high or the drainage is retarded by a hardpan or a heavy clay layer.

The best soils are those with subsoils that have enough clay to provide an adequate moisture and nutrient reservoir and yet have enough sand and silt to provide satisfactory internal drainage. A uniform, brightly colored subsoil indicates good drainage.

Subsoils that are white or light gray or are streaked with dull-gray, brown, and yellow mottlings have poor drainage. Other soils may be much too sandy, thus being especially low in moisture, in fertilizer-storing capacity, and in fertility. It is possible to grow good tung trees on such soils, but they require heavy and continuous fertilization and other special care; thus, the cost of production is higher than on heavier, well-drained soils.

SOIL ACIDITY

Soil acidity is usually measured in terms of pH. Soils that register 7.0 are neutral, soils below 7.0 are acid, and those above are alkaline. A soil with a pH of 6.5 or above is considered very slightly acid, one with a pH of 6.0 moderately acid, with a pH of 5.0 strongly acid, and with a pH of 4.0 extremely acid.

Most soils of the Tung Belt are moderately to strongly acid, ranging from pH 6.5 to 4.5, with most having a pH of less than 6.0. Although the tung tree is tolerant of strongly acid soils, leguminous cover crops grow best at a pH of 6.5 to 6.0 (very slight to slight acidity), with growth decreasing moderately as soils become alkaline and rapidly as they become more acid than pH 6.0. Therefore, liming would probably be beneficial to most soils in the Tung Belt, with lime being needed in increasing amounts as acidity increases.

Phosphorus if present in the soil is available to plants in alkaline to slightly acid soils, but it decreases rapidly in availability as the soils become more acid. Very strongly acid and extremely acid soils supply almost no phosphorus.

Maximum availability of zinc, copper, and manganese to plants is found in soils that are strongly to very slightly acid. The availability of these elements begins to decrease at about pH 6.5 and under alkaline conditions they are likely to be unavailable. A discussion of fertilizer requirements begins on page 29.

SOIL TYPES

Ruston sandy loam is one of the most desirable types of soil for tung trees. This soil occurs extensively throughout the Tung Belt except in peninsular Florida. The surface is a grayish-brown sandy loam, and the subsoil is a uniform brown, friable, sandy clay loam.

Closely associated with Ruston in soil type and location and equally good for tung are the Orangeburg, Red Bay, and Norfolk sandy loams. The Orangeburg and Red Bay subsoils are red, friable, sandy clay loams and the Norfolk subsoil is a yellow, friable, sandy clay loam. Other excellent but less extensive soils for tung are Greenville, Marlboro, Magnolia, Faceville, Carnegie, and Tifton.

In peninsular Florida, the Gainesville and Arredondo loamy sands and sandy loams are well suited to tung growing.

Extensive plantings of tung have been made in Mississippi and Louisiana on Ora, Dulac, Savannah, and Franklinton very fine sandy loams. These soils have proved satisfactory for tung production, although they are somewhat less productive than those mentioned above. The Ora and Dulac soils have a relatively heavy and compact subsoil, but they are sufficiently well drained to permit good growth. Although the Savannah and Franklinton soils have a weakly cemented hardpan in the subsoil, they are moderately well drained.

Susquehanna is an example of a soil definitely unsuited to tung growing. Close to the surface of this soil is a subsoil of highly mottled, red, light-gray, and brown clay, plastic and sticky when wet and extremely hard when dry. The internal drainage is entirely inadequate, and trees planted on this soil have grown poorly if at all. The same is true of Caddo very fine sandy loam, which is found in upland flats. Tung has done poorly also on Leon and Fellowship soils in peninsular Florida because of poor drainage.

In Mississippi and Louisiana, Pheba and Lewiston fine sandy loams have been planted extensively to tung. These soils have not been satisfactory, because of a hardpan within 12 to 30 inches of the surface, which seriously restricts drainage.

Large acreages of tung have been planted on deep sandy soils such as Lakeland and Blanton fine sand, but many of these orchards have failed. These soils are low in moisture- and fertilizer-holding capacity, and their fertilizer requirements are much greater than those of the heavier soils. Under some conditions these soils may produce successful tung orchards, but they are not recommended.

PREPARATIONS FOR PLANTING

After the site of the new orchard has been selected, the first task is to clear the land. This involves removing all stumps, brush, and litter. Stumps interfere with cultivation and may damage machinery. They are also expensive to remove once the tung trees are established.⁶

Land may be prepared for planting by plowing and disking, or disking either the entire field or rows 12 to 18 feet wide where trees are to be planted. Preparation in the rows should be thorough so that cultivation of the trees later on will be easier.

Because tung is grown in an area of heavy rainfall, tree rows should follow the contour of the land, and slopes of 3 percent or more should be terraced.

The trees should be planted on the tops of the terraces. Greater topsoil accumulation and better soil aeration promote growth and production; also, terraces between the rows of trees interfere with cultivation in the mature orchard. The terraces should be broad with gradual slopes, making it possible to bring cultivating machinery close to the trees when they are young.

Orchard terraces are normally not so high as terraces for general farming but are broader and more closely spaced. At the steepest point on the slope the terraces should be spaced at minimum tree-row intervals. From this point they are projected in both directions by use of an engineer's level and rod and the distance between

⁶ U. S. Department of Agriculture Farmers' Bulletin 1526, Clearing Land of Brush and Stumps, is available from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. for 10 cents.

them will grow wider where the slopes are not so steep. "Point rows" of trees may be planted between the terraces where space permits. Cultivation will build up soil in the point rows and eventually they will serve as terraces. Because of this, point rows must follow a grade that will allow water draining from them to flow toward the outlet and discharge into either the outlet or the next lower terrace. This may be accomplished by following the rule that as one proceeds toward the outlet when the terraces are converging, the point rows should parallel the upper terrace, and when the terraces are diverging, the point rows should parallel the lower terrace.

The following method simplifies laying off the point rows: A ball of twine is used with streamers tied to mark the proper intervals between rows, for example at 35-foot intervals. Starting at the beginning point of water flow, one person takes the ball of twine and walks the upper terrace toward the outlet. Another person takes the end of the string and walks the adjacent (lower) terrace, keeping abreast of the one on the upper terrace. As they proceed toward the outlet the person on the upper terrace may unwind string but never rewind it, and the one on the lower terrace may take up slack but never give back any string. As these two persons walk the terraces, other persons should follow the streamers, setting stakes at convenient intervals to mark the tree rows.⁷

Tung may be planted on land that has standard field terraces of broad base and proper grade. Full rows of trees should be planted on the terraces; and point rows, planted between, are laid out as described above.

If standard field terraces are closer than the minimum distance required between tung tree rows, the slope is probably too steep for planting tung. This also holds true if, in constructing new terraces at minimum spacing, it is found that the drop in elevation from one terrace to the next lower terrace is greater than can be allowed for the soil type, expected rainfall, and cultural conditions.⁸

DIVERSIFICATION

Almost every farm in the tung area contains some acreage that is not suitable for tung production, usually because of inadequate air or water drainage, or the shallowness of the soil. Fuller use of the land can be obtained by producing companion crops or products in addition to the tung trees. Certain pasture grasses, legumes, or combinations of these can be used to establish productive pastures on land unsuited for tung. To be successful, pastures must be properly established and managed and grazing must be controlled. It does not pay to have the permanent pasture in the orchard, but after the trees are 3 or 4 years old, leguminous cover crops growing in the orchard may be grazed to a limited extent.

There are many companion crops that can be grown satisfactorily in a tung orchard while the trees have not yet fully occupied the land. Row crops that must be cultivated improve cultural conditions

⁷ From Miss. Agr. Expt. Sta. Bul. 464, Tung Culture in Southern Mississippi, p. 10. 1949. (Revised.)

⁸ More detailed information on terracing is available in U. S. Department of Agriculture Farmers' Bulletin 1970, Conserving Moisture in Orchards and Vineyards. This bulletin is available for 10 cents from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.

in the orchard, increase the fertility of the soil, and provide substantial income to help keep the tung investment low. Some satisfactory crops for this purpose are field corn, cotton, strawberries, peanuts, sweet corn, sweetpotatoes, field peas, beans, cabbage, and melons. Tall-growing crops like field corn should not be planted so close that they will shade the young trees.

The county agricultural agent should be consulted for further information on the production of companion crops, the establishment of permanent pastures, or beef production. Another source of information on local problems is the State agricultural experiment station. Publications of the United States Department of Agriculture are also available to the farmer.

PLANTING STOCK

SEEDLINGS AND BUDDED TREES

Seedlings or budded trees may be used to start a tung orchard.

Nearly all of the commercial tung orchards in the southern United States were started with seedlings, although 200,000 to 300,000 budded trees were also used.

Seedlings generally differ considerably from the parent trees in their growth and fruiting characteristics. In the process of seed formation a redistribution of characters takes place so that those inherited by one seedling are never all identical with those of another. Seedling progenies of plants that have been self-pollinated for several generations may rather uniformly resemble the parent, however.

The seed from about 1 tree in 100 outstanding trees will produce seedlings suitable for commercial orchard planting. Thus, to tell whether a selected tree will make a satisfactory source of seed one would have to grow a large number of its seedlings to maturity and then judge the parent by the characteristics of the seedlings. This is called a progeny test, and only trees so tested should be used as sources of seed for planting commercial orchards.

After a tree has been progeny-tested it may be propagated by budding. The budded trees, which are hereditarily identical with the original tree, will produce seed satisfactory for planting.

Seedlings are used to provide a root system for budded trees. Buds from parent trees are transplanted to the stems of 1-year-old seedlings at or near the surface of the soil. Later the original seedling top is cut off and a new top is grown from the transplanted bud. Thus the tops of the budded trees are parts of the parent trees and the mature budded trees exhibit the same characteristics as the parent trees. Characteristics of the seedling roots may sometimes affect rate and extent of growth and fruitfulness of the budded trees, however.

Experiments of the United States Department of Agriculture are now in progress in which seedlings from the best progeny-tested parents are compared with budded trees of the same parentage. Up to 4 years of age, the seedlings have grown more vigorously than the budded trees. On the other hand, slightly larger crops have been produced by the budded trees. It is possible that when the larger seedling trees become mature they will yield as much as or more than the budded trees. The budded trees are somewhat more uniform than the seedlings in productivity, oil content, and date of maturity of the fruit.

At prevailing prices for nursery stock (1951), the 100 budded trees generally planted on an acre of orchard would cost about \$20 more than the same number of seedling trees. Experiments must be continued for several more years to determine whether or not the budded trees are worth the extra cost.

The United States Department of Agriculture has released six varieties of budded tung trees that are now available commercially. They are as follows:

Cooter.—A low-headed variety of high productivity. It has produced outstanding yields in experiments. The fruits mature early, are of medium size, and the oil content is about 20 percent.⁹

Gahl.—A low-headed, productive variety that bears large-sized fruits with an oil content of 20 percent or slightly more. This variety matures fairly early and has proved to be exceptionally resistant to cold injury.

Isabel.—A low-headed tree of very high productivity; bears good-sized fruits that mature early and contain approximately 23 percent oil.

La Crosse.—A high-headed variety of exceptional productivity. The fruits are small and they mature late in the season, but they have a high oil content that ranges from 21 to 22 percent. This variety is very popular with many growers, especially with those who feel that it is difficult to cultivate low-headed trees.

Lamont.—A high-headed variety of high productivity, rather resistant to cold injury. The fruits mature somewhat later than those of Gahl and are variable in size. The oil content is about 19 to 20 percent.

Lampton.—In tests, this latest addition to the list of budded varieties has out-yielded all the others. It is a very low-headed tree that bears large-sized, early-maturing fruits with an oil content of about 23 percent, equal to that of Isabel.

First-generation seedlings of Lampton and La Crosse are very true to parent type. Gahl and Isabel produce 25 to 30 percent of off-type seedlings. These off-type seedlings are worthless for planting and should be destroyed. They can be detected and destroyed in the nursery stage of growth and the true-to-type seedlings can then be used for planting. Seedlings of Lamont and Cooter are so variable that they are not worth planting commercially. These two varieties should be planted only as budded trees.

Seedlings of selections known as L-46 and L-47,¹⁰ of selections made by the Florida Agricultural Experiment Station known as F-2 and F-9, and of a tree called the McKee have been widely planted. At the time, they were among the best trees available. However, it is believed that none of these is now equal to the newer varieties just released.

Every effort should be made to obtain first-generation seed for planting; that is, seed from the original tree or from budded trees propagated from the original tree (fig. 3). In recent years demand for seed of the new varieties released by the United States Department of Agriculture has often exceeded the supply. Only small quantities of seed from the original tree or from budded trees were available. Because of this many growers have used seed from seedlings of the original tree (second-generation seed). On the basis of natural laws of inheritance, it was anticipated that variations observed in seed-

⁹ The oil content of the whole tung fruit varies inversely to its moisture content. Oil-content data in this bulletin are based on a 15 percent moisture content of thoroughly air-dried fruit.

¹⁰ In breeding and selection work by the Bureau of Plant Industry, Soils, and Agricultural Engineering, each selection has been given a letter and a numeral to indicate the State in which it originated and progressive numbering of selections made in the State.



Figure 3.—These 1-year-old seedling trees of the Isabel variety were obtained by planting first-generation seed and then selecting trees that showed a low-branching habit. They are planted on the contour and strip-cultivated along the rows.

lings from the original trees would tend to increase in successive generations. Results with tung trees grown from second-generation seed confirm this view.

THE NURSERY

A supply of the progeny-tested seed should be arranged for well in advance of nursery-planting time. Requirements for a nursery site are basically the same as those for an orchard. The site should be in an upland location so that air drainage will reduce the risk of cold injury to the young plants; the soil should be friable, well drained, have an adequate moisture- and nutrient-holding capacity, and be reasonably fertile. The site should be plowed in the fall and harrowed three or four times in the spring before seed is planted.

Tung seed is normally short-lived and must be planted during the season following its harvest. The fruit should be hulled before planting, even though it is easier to break it into segments, each segment consisting of a seed and the adhering hull. Leaving the hull on the seed retards germination.

Hulled seed may be planted dry. However, earlier germination may be obtained by soaking the seed in water for 2 to 5 days before planting. Also, other treatments generally cause more satisfactory germination. These include stratification, cold treatment, and chemical treatments.

In stratification, seed is placed in moist sand as soon as possible after harvest (not later than the last of December) and left outdoors until planting time. A wooden frame 10 to 12 inches deep is placed in a well-drained, preferably shaded, site and a 3-inch layer of clean,

moderately coarse sand is placed in the bottom of the frame. Single layers of hulled seed are alternated with $\frac{1}{2}$ - to $\frac{3}{4}$ -inch sand layers until the frame is nearly full. It is then capped with 3 to 4 inches of sand. Stratified seed must be inspected frequently in the spring and planted before it germinates.

In cold treatment the hulled seeds are placed in moist wood shavings and kept at a temperature of about 45° F. in a cold-storage room for 30 to 40 days before planting. The effect of this treatment is much the same as that of stratification.

Chemical treatment also accelerates germination but somewhat less effectively than stratification or cold treatment. The best chemical treatment consists of soaking the hulled seed in 1-percent morpholine solution in a nonmetal container for 48 hours before planting. The advantage of the cold treatment or chemical treatment over stratification is that less time is required and there is no danger of premature germination; planting can be done whenever weather and soil conditions are favorable.

Dry-stored tung seed should be planted early, not later than February. Stratified seed should be planted about the middle of March. The cold-treated and chemically treated seed may be planted advantageously as late as the first week in April, excepting in localities subject to spring drought. In those areas it is advisable to plant early enough for germination to be completed and growth well started before the dry weather begins. The seeds are usually planted either by hand or with a modified corn planter. They are spaced 6 to 8 inches apart and placed about 2 inches deep in rows that are at least 5 feet apart.

The nursery must be kept free of grass and weeds during the growing season if large, superior-quality seedling trees are to be produced.

Seedlings from dry seeds generally do not come up for 60 days or more, and weed control often becomes a serious problem. For this reason newly cleared land, which is relatively weed-free, is preferred for a dry-seeded nursery. Seed is sometimes planted 4 or 5 inches deep under "beds" of soil thrown up with a "middle buster" or a single-disk harrow. The extra soil is "barred off" with a drag or spike-tooth harrow just before the tung seedlings are expected to come up, thus destroying weeds.

The use of stratified, cold-treated, or chemically treated seed, which is planted late, makes it possible to kill the weeds by disking repeatedly for 4 to 6 weeks before planting. The rapid and uniform germination effected by these treatments permits easier weed control because the barring-off, hoeing, and cultivation may be started soon after the planting date.

Experiments with weed killers such as 2,4-D and TCA ¹¹ as controls before the seedlings emerge give promise but have not yet reached the stage of practicability.

As soon as the seedlings can be seen, they are side-dressed with fertilizer, the amount and composition of which will depend somewhat on the soil. In the western part of the Tung Belt nitrogen and phosphorus are the two most important elements required, but it is customary to use a 5-10-5 fertilizer at the rate of 500 pounds per acre, which is about 6 pounds per 100 feet of row. The fertilizer is applied

¹¹ 2,4-Dichlorophenoxyacetic acid and sodium trichloroacetate, respectively.

in bands along each side of the row about 8 inches from the seedlings and at a depth of 2 to 3 inches. If the soil is known to be deficient in zinc, or if bronzing (result of zinc deficiency) develops on the tree, a supplementary application of commercial zinc sulfate, containing 36 percent metallic zinc at the rate of about 1 pound per 100 feet of row, or 90 pounds per acre, should be made. In the eastern part of the Tung Belt a mixed fertilizer of 6-6-6 or 8-8-8 composition is preferred, and the mixture should also contain zinc (3 percent zinc oxide), magnesium (3 percent magnesium oxide), copper (0.5 percent cuprous oxide), and manganese (0.5 percent manganese oxide).

Tung varieties like Lamont and Cooter, which do not come true to variety from seed, must be propagated by budding. Two years are required to produce satisfactory budded trees. Attempts to produce budded trees in a single season by budding the young seedlings (14 to 18 inches high) in July following planting of seed in March or April have met with only fair success. Root grafting and propagation by cuttings have not proved successful.

The productivity of the budded tree is sometimes affected by the seedling used as a rootstock. Among trees tested, the progenies of L-99 and F-2¹² have been found best for rootstocks.

It is advantageous to use a rootstock that can be grown as a seedling in case the bud of the new tree does not take. Seed of the La Crosse or Lampton varieties, previously listed as satisfactory seed parents, would be suitable for this purpose.

BUDDING

Budding is done by the simple, effective shield method. This requires a piece of budstick bark, including a bud, that will fit into a cut in the rootstock bark.

Vigorous budwood shoots of the current season are cut just before they are to be used from mature trees or from nursery stock that is true to variety. The leaf blades are cut from the budsticks, leaving a short piece of petiole (leafstalk). If buds form they are always in the axil (upper angle between the petiole and the stem). After preparation, the budsticks should be wrapped in a damp cloth to prevent drying. At the time of budding, shield-shaped pieces of bark, including the bud, are cut from the budsticks.

A T-shaped cut, large enough to receive the budstick shield, is then made in the bark of the rootstock at a point 2 or 3 inches from the ground. The flaps of bark are loosened. Using the petiole as a handle, the shield-bud is now slipped inside the flap of bark on the rootstock. The flaps are tied down tightly over the transplanted bud with a rubber budding strip (fig. 4). Recommended strips are 5 inches long, $\frac{3}{16}$ inch wide, and .016 gage.

After about 7 days the rubber strip is cut to prevent binding the bud too tightly as the rootstock increases in size. Budding is most successful when the rootstocks are in active growth. The best period for budding is generally late August, when the seedlings have attained good size and are still growing vigorously. As the newly set buds are susceptible to cold injury, soil is mounded over them before cold weather begins. When growth starts in the spring, the soil is pulled away and each stock is cut back to within an inch and a

¹² See footnote 10, p. 12.

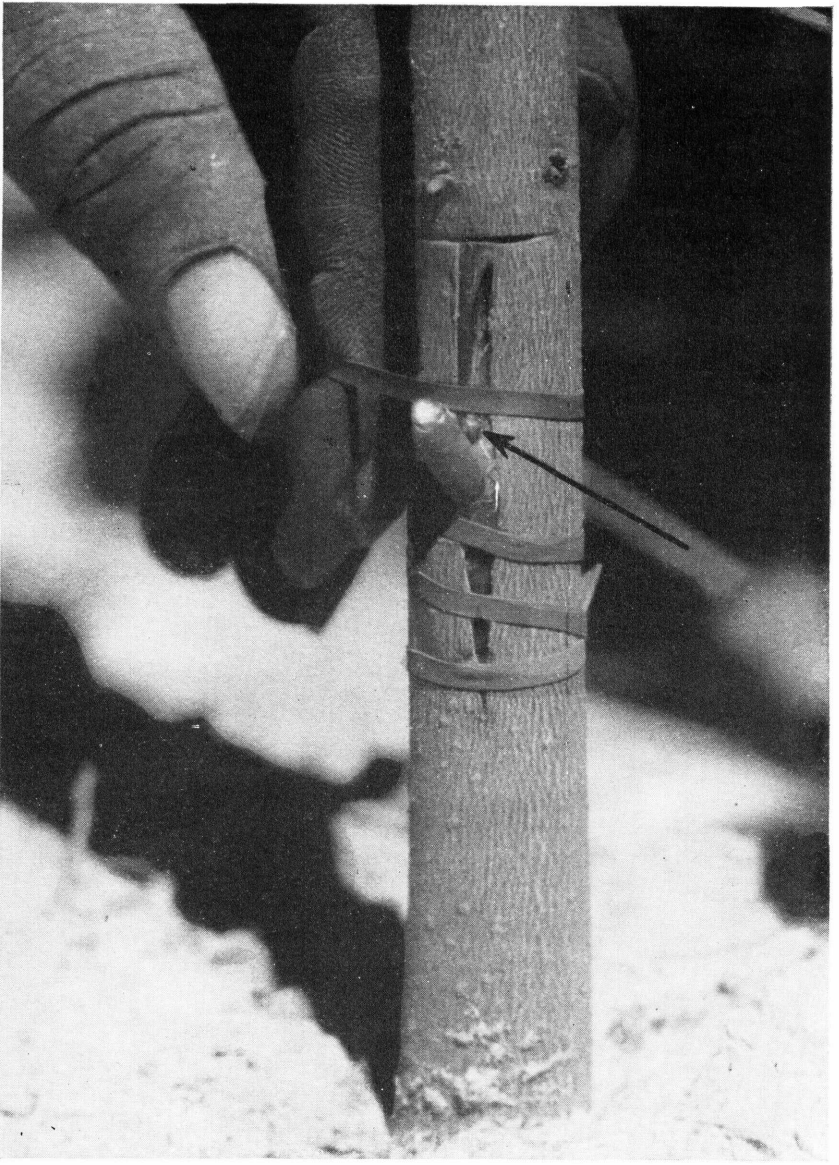


Figure 4.—This shield-bud, or T-bud, has been inserted under the flaps of bark on the rootstock and is being wrapped with a rubber budding strip. Bud is indicated by arrow.

half of the dormant bud in order to force it into growth. Later care consists of keeping all suckers removed and the trees well cultivated. The trees are transplanted to the orchard late the following winter.

Spring budding is done just as soon as the bark of the budsticks and rootstocks will slip; and the buds are forced as soon as they have set, usually about 10 days to 2 weeks after the budding operation. Budding is done in the spring only as a last resort if the necessary trees were not propagated the previous fall.

PLANTING THE ORCHARD

The number of trees planted per acre may vary from 50 to 300. The tung tree bears only on the ends of shoots produced the previous year and largely in the outer portions of the tree. When the trees are small, close planting in the row greatly increases the bearing surface, but at maturity the bearing surface of a crowded, or "hedge," row is about the same as that of a row in which the trees are farther apart. Close planting in the row will increase early yields and also shade out weeds and grass between the trees. It is well to leave enough room between rows for orchard operations, however.

Rows 30 to 35 feet apart with trees spaced 10 to 12 feet in the row will give about 100 to 140 trees per acre,¹³ which will provide reasonable production at an early age with adequate room for cultivating and harvesting. The best distance depends also on economic considerations that vary with the individual grower. The cost of land and clearing and of trees and care must be considered. Since an acre of closely planted trees is worth no more at 7 or 8 years of age than an acre of trees planted 12 feet apart in 35-foot row spacings, the total acres of bearing orchard that may be had for a given initial investment is a major consideration. Total production from the mature orchards will be about the same, and a smaller investment will have been made in the orchard with the more widely spaced trees.

The orchard should be planted with nursery stock or seed in January, February, or March. As a rule growers will obtain the most satisfactory results by planting selected nursery trees. The cost of growing seedlings in a nursery and then transplanting them is greater than planting seed directly in the field, but savings are gained in the cost of cultivation for the first year. Planting seed in the orchard requires intensive cultivation of the whole orchard to insure adequate tree growth and good branch structure. Also, when seed is planted in the orchard, the opportunity to select the best type of seedling is limited.

If nursery stock is used, it will pay to discard all trees not true to type, because even the best seed produces some poor trees that will be consistently unprofitable if transplanted to the orchard.

Nursery trees can be dug by hand or with a commercial nursery-tree digger. The main roots should be severed about 1 foot below the surface of the ground and the lateral roots about 1 foot from the trunk. The roots should not be exposed long to the air. Trees that are to be transported for some distance should be packed well with damp hay, straw, or similar material. If it is not convenient to plant immediately at the orchard site, the trees may be heeled in (roots are temporarily covered with earth, with care taken to leave no air pockets).

Trees should be transplanted to the same depth they were in the nursery, or 1 or 2 inches deeper. Transplanting holes may be dug by hand or mechanically. They should be large enough to accommodate the root system without crowding or further pruning.

Two men can work together very effectively in transplanting. As one man shovels, the second man can hold the tree at the proper depth, continually working the soil in around the roots and moving or

¹³ In contour plantings, distances between rows and total number of trees per acre vary.

“jiggling” the tree to insure even packing. It is important to start packing the soil around the roots with the first shovelful of earth.

PRUNING AND TRAINING

NATURAL-FORM TRAINING

Pruning the tops of nursery trees at the time of planting results in more vigorous growth and a better framework of branches. Low-heading varieties such as Isabel, Lampton, Cooter, and Gahl may be cut back to 8 or 10 inches. As growth starts, all buds are rubbed off except the one strongest growing and best placed on each tree. A bud that starts 2 inches or more below the top of the stump is preferred over one closer to the top. Forcing the growth into one bud should result in a “natural-form” type of tree, well branched at the end of the first year (figs. 5 and 6).

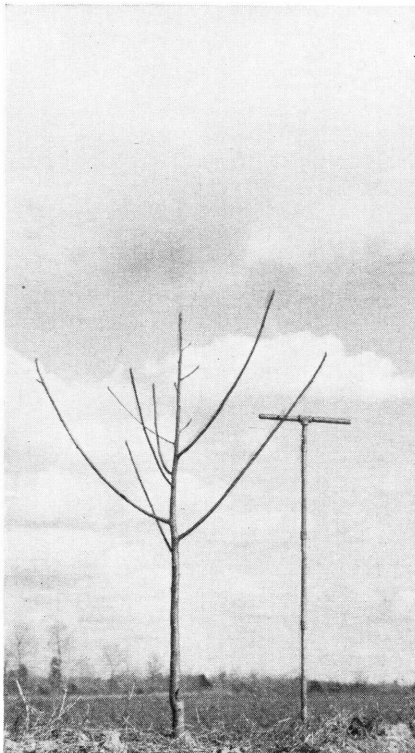


Figure 5.—Low-headed tree of the Lampton variety trained to the natural-form as it appeared at the close of the first season in the orchard. Trees of low-heading varieties generally start bearing sooner than those of high-heading varieties.

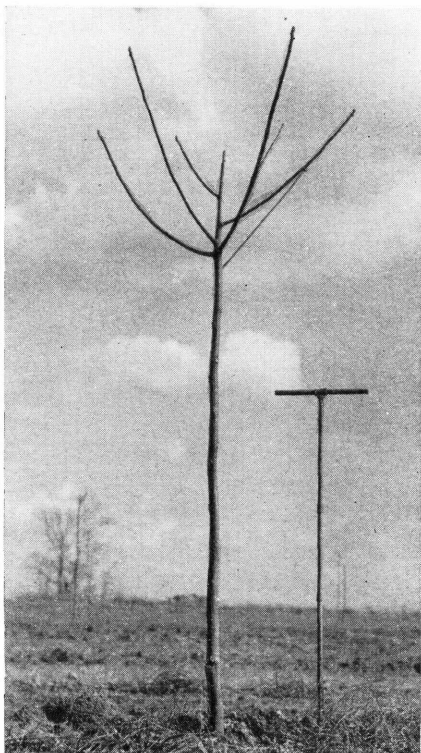


Figure 6.—High-headed tree of the Lamont variety trained to the natural-form as it appeared at the close of the first season in the orchard.

VASE-FORM TRAINING

If conditions during the first growing season in the orchard are unfavorable the trees may fail to branch. If so, they usually throw out

a whorl of four or five lateral branches from growing points within the terminal bud when growth starts the second year. Known as cartwheels, these trees are structurally weak and often break under the strain of heavy crops and high winds. To prevent this, the unbranched trees are cut back to a height of 16 or 18 inches at the beginning of the second season. All buds that force out are allowed to grow, forming what is known as a vase-form type of tree (fig. 7).

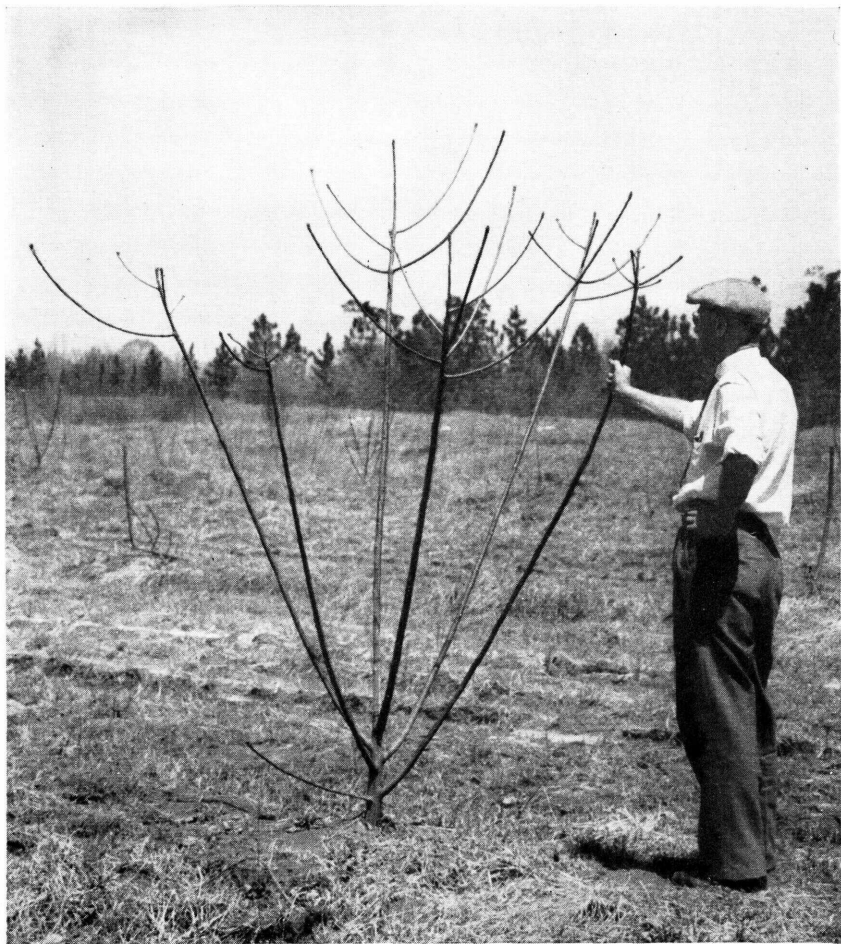


Figure 7.—A tree of the high-heading La Crosse variety that has grown well after being trained to vase-form at planting time. It is shown at the end of the first season in the orchard.

Most growers prefer to train to the natural-form, although training to the vase-form at time of planting will bring about the highest production per tree with high-heading varieties like La Crosse and Lamont.

Smaller production per tree with natural-form training can be compensated for by planting more trees to the acre.

Vase-form trees break badly if they undergo heavy stress, as by hurricane winds, during early years in the orchard. A poor tree of the

vase-form type is not only weak but also fails to attain high early yields. Therefore, certain precautions must be taken in training to this form:

(1) The nursery tree planted must be of good size. It is inadvisable to train trees to vase-form that are less than 1 inch in diameter at 16 inches above the ground. As a rule the larger the tree the greater the number of buds that will be forced into branches.

(2) At planting time, the tree is cut back to a height of 30 inches. Then, when growth first becomes evident, the tree is further cut back to the 14- to 16-inch level. All buds that start are then allowed to grow. If cut higher, or if cut to 14 to 16 inches at planting time, fewer buds will force.

(3) Good culture must be provided to force satisfactory growth.

Figure 8 shows an ideally branched tung tree, figure 9 shows one that is poorly formed, and figure 10 shows the effect of a weak branch-to-trunk union.

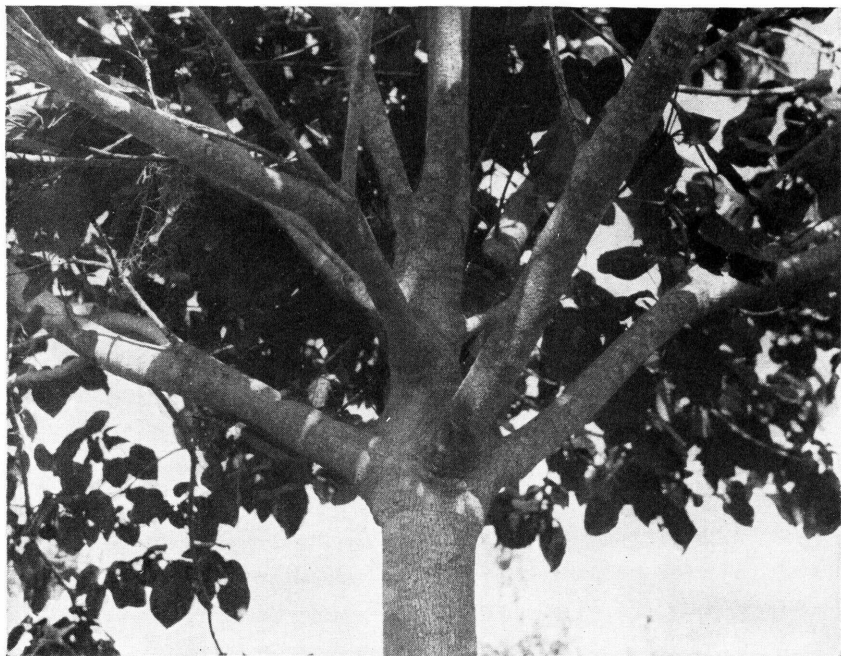


Figure 8.—The framework of this tree shows elements of strength: The branches are well spaced along the trunk, there is a wide angle between the branches and the main trunk, and the leader branch is larger than any lateral branch.

CULTIVATION AND COVER CROPS

For best growth, young trees must be kept free from competition with weeds and grass from April to about the end of June. There is reason to believe that the same is true of bearing tung orchards.

Also, for success in tung culture, it is essential to grow and to incorporate into the soil a leguminous green-manure or cover crop.

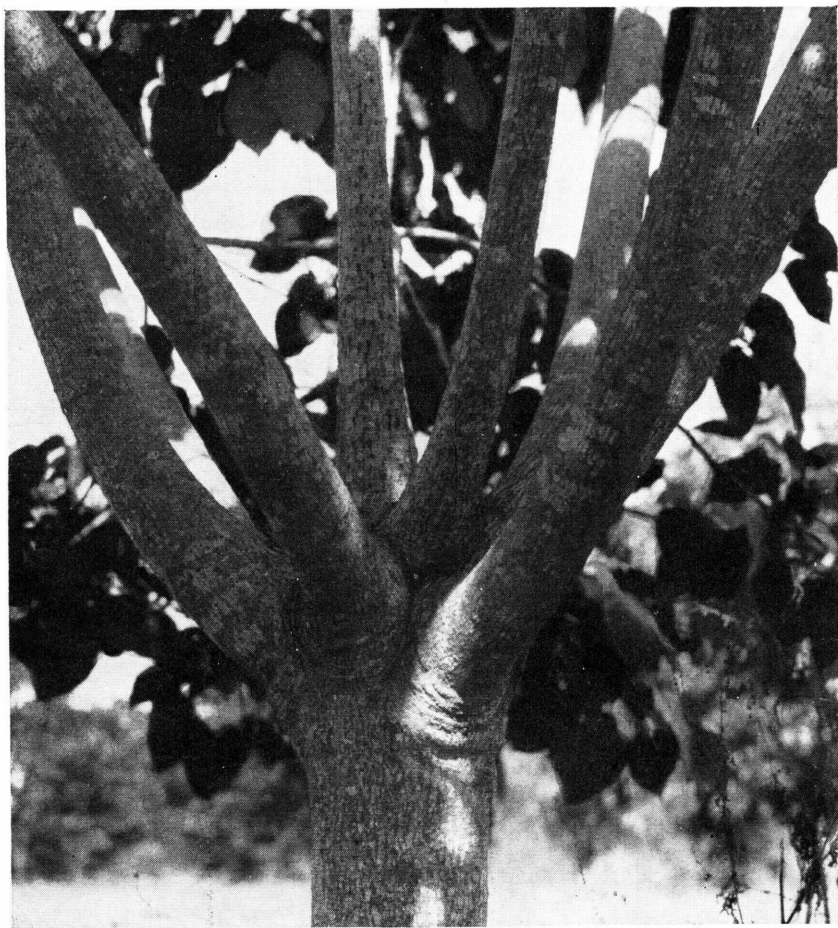


Figure 9.—Elements of weakness are shown in the framework of this tree: The branches are crowded near one point on the main trunk, there is an acute angle between the branches and the trunk, and there is no strong leader branch.

The grower has a choice of using either a winter or a summer cover crop (table 2), and the schedule of annual cultivation must depend largely upon this choice.¹⁴

¹⁴ The following publications of the U. S. Department of Agriculture, available from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., at the prices shown, give detailed information on the culture of cover crops:

Farmers' Bulletins: 1148, Cowpeas, Culture and Varieties, 10 cents; 1980, Crotalaria, Culture and Utilization, 10 cents; 1946, Lupines, New Legumes for the South, 5 cents; 1803, Culture and Pests of Field Peas, 5 cents; and 1740, Vetch Culture and Uses, 5 cents.

Leaflets: 160, Crimson Clover, 5 cents; and 119, White Clover, 10 cents.

Information on culture of beggarweed, indigo, and wild winter peas is contained in the mimeographs, Beggarweed, Hairy Indigo, and Roughpeas, that are available free from the Division of Information, Bureau of Plant Industry, Soils, and Agricultural Engineering, Plant Industry Station, Beltsville, Md.

TABLE 2.—Principal cover crops for tung orchards

Common name	Scientific name	Planting date	Seeding rate per acre	Turning date
Alyceclover.....	<i>Alysicarpus vaginalis</i>	June or early July ¹	<i>Pounds</i>	August to September.
Beggarweed.....	<i>Desmodium purpureum</i>	June ¹	10 to 15	Do.
Crimson clover (reseeding).....	<i>Trifolium incarnatum</i>	October ¹	10 to 15	April.
Common white clover.....	<i>Trifolium repens</i>	do	15 to 20	April to May.
Cowpeas.....	<i>Vigna sinensis</i>	May to June.....	15 to 20	August to September.
	<i>Crotalaria intermedia</i>	} do ¹	20	Do.
Crotalaria.....	<i>C. mucronata</i>			
	<i>C. lanceolata</i>			
	<i>C. spectabilis</i>	} June	7	Do.
Indigo.....	<i>Indigofera hirsuta</i>			
Blue lupine ²	<i>Lupinus angustifolius</i>	October	50 to 100	April to May.
Austrian Winter peas.....	<i>Pisum arvense</i>	do	30	April.
Wild winter peas ³	<i>Lathyrus hirsutus</i>	do ¹	25	May. ⁴
Common vetch.....	<i>Vicia sativa</i>	do	25	April to May.
Hairy vetch.....	<i>Vicia villosa</i>	do	20	Do.

¹ There should be volunteer stands after the first seeding.² Seed should be covered to depth of 2 inches.³ Also known as Singletary pea, roughpea, and Caley pea.⁴ Or as soon as seeds are ripe.



Figure 10.—A weak union results when a branch makes a sharp angle with the trunk during rapid growth of the tung tree. Note triangle of bark at the crotch (circled), showing extent of separation of branch from trunk before the split occurred.

Winter cover crops, generally sown in late September or early October, grow rather slowly through the winter and are ready to be turned under in April or early May. Cultivation of the soil may be continued through the summer until time to plant the cover crop again. In most of the tung-growing areas, however, heavy rains are likely to occur during the summer months and it is good practice to stop cultivation late in June. This will provide a cover of native vegetation to protect the soil during the rainy summer months. From mid-August to early September the orchard should again be cultivated to prepare for harvest and for reseeding of the cover crop.

The cultural schedule that includes summer cover crops should be arranged so that the crops will make their growth during the summer months when rainfall is usually heaviest. Cultivation of the orchard will commence in early spring, frequently as early as late February or early March, and will continue intensively until about the middle of

June. Summer legumes grow vigorously and will generally produce a satisfactory tonnage of green manure between the middle of June and the middle of August. At that time the orchard is usually strip-cultivated with the cover crop being turned under in strips next to the tree rows. This facilitates harvesting and prevents the cover crop from competing with the trees for moisture during the fall when precipitation is usually at a minimum (fig. 11).

Strips of a cover crop like crotalaria, remaining in the middle of the rows, will reseed the entire area. Cover crops like alyceclover will provide seed for replanting. Such strips also protect the soil against erosion during the winter.



Figure 11.—This summer cover crop of alyceclover was turned under along the tree rows to prevent competition for moisture during the dry fall months and to facilitate the harvest.

Evidence from tung cultivation tests indicates that the principal benefit of cultivation is the elimination of grass and weeds. Therefore, shallow cultivation, just deep enough to destroy this competing growth, is desired.

If a mulch deep enough to kill out grass and weeds is used, young tung trees grow just as well or better than if intensive cultivation is used. As a rule such mulching is feasible only with young trees, as too much material would be required to be of value for older trees.

In older tung orchards grass and weeds are often killed out by shade. In fact, when the trees are large enough to form a complete canopy over the soil, there is very little competing growth and little cultivation is required. Such orchards need cultivation only to work fertilizer into the soil in the spring. There is no reason to believe that

additional cultivation would be beneficial. Because cover crops cannot be grown under such complete shade, the only green manure that will be added to the soil will come from fallen leaves. With minimum cultivation, however, there is a minimum loss of organic matter. Therefore, leaves alone may maintain a satisfactory level of humus in the soil.

Method of cultivation and choice of implements depend mostly on orchard conditions and the grower's preference.

Row-crop equipment, either horse- or tractor-drawn, may be used to advantage in the newly planted orchard. When the trees are first planted the rows may be straddled and later in the season the row-crop cultivator may be operated on each side of the tree rows.

In older orchards the first operation of the season is generally the turning under of a cover crop, for which the disk tiller, wheatland plow (fig. 12), or the one-way disk plow (fig. 13) may be used. This



Figure 12.—The disk tiller, or wheatland plow, is an excellent implement for turning under cover crop or native growth.

work is also often done by using an offset disk harrow (fig. 14). Land between tree rows may be worked out with a tandem disk.

For the maintenance cultivation that follows, a spring-tooth harrow is an excellent implement that may be used to cover a large number of acres daily at low cost. This harrow is not suited to destroying heavy weed growth, however, and unless cultivation is frequent some type of disk is preferable.

In addition to machine cultivation, some hand hoeing is always necessary, particularly to destroy the volunteer tung trees that grow from fruit missed at harvest. These trees will grow even in shade too dark for most weeds, and the most economical method is to get rid of them while they are small by hoeing them out regularly each season.



Figure 13.—This tractor with guard is being worked close to the tree row with a one-way disk plow. The guard rarely damages the tung branches.



Figure 14.—The offset disk harrow is ideal for cultivation under the branches of the tung trees.

The poisoning of cattle from eating green and partially dried leaves from cut tung branches has been reported.¹⁵ However, no trouble from poisoning has been experienced in July and August, when tung volunteers are usually cut. At that season the animals have plenty

¹⁵ See Fla. Agr. Expt. Sta. Bul. 376, Tung Tree Foliage Poisoning of Cattle, 1942.

of other food, which they prefer to the tung leaves. Therefore, it is not necessary to remove the small trees, even from orchards that are pastured.

WINTER COVER CROPS

Most winter cover crops grow rather slowly during the winter months and make the major part of their growth in early spring at about the time the tung trees are coming into leaf. They are particularly useful in orchards where the intense shade of fully developed tung foliage of midsummer would greatly curtail the growth of summer cover crops. Most of the winter cover crops must be seeded annually. When such crops are used a recommended rotation would include hairy vetch, common vetch, and Austrian Winter peas. Blue lupine should be included in the rotation in those areas where it can be grown, as in the more sandy soils of the tung-producing areas of Alabama, Georgia, and Florida.

Because tung fruits drop to the ground at the season when winter cover crops are sown, a satisfactory self-seeding winter cover crop would be of great value to tung orchardists. Wild winter peas, the varieties Dixie and Autauga¹⁶ of crimson clover, and common white clover are used by some tung growers as self-seeding winter cover crops. As a rule the seeds do not mature until late in the season; therefore the early cultivation so essential to the tung orchard must be sacrificed. Under favorable conditions white clover or crimson clover may make a heavy mat over the surface of the ground. This suppresses other growth and acts as a mulch, making early cultivation less essential.

SUMMER COVER CROPS

Excellent summer cover crops can be grown throughout the whole Tung Belt (table 2). Among those most commonly used are four species of crotalaria—*Crotalaria intermedia*, *C. macronata* (formerly *C. striata*), *C. lanceolata*, and *C. spectabilis*—and alyceclover. The *spectabilis* species of crotalaria is highly satisfactory for the production of green manure and is the only cover crop that can be recommended for use in unfenced orchards of open range country. Although *C. spectabilis* is poisonous to cattle, they will not readily eat it.

On some of the lighter tung soils of Alabama, Georgia, and Florida, beggarweed makes a rather satisfactory summer cover crop. Hairy indigo has been used in a limited way and has produced good stands even on sandy soils. Soybeans or cowpeas may also be used. Common lespedeza has been tried in some orchards, particularly where growers have hoped to provide pasture between the rows of trees. This crop forms a tight sod early in the season, however, when the tung trees are in the greatest need of cultivation, and has seriously restricted tree growth and fruit production wherever it has been used.

It is sometimes advantageous to mow the summer cover crop rather than to disk it under. Weed choppers (fig. 15) are efficient implements for this work because of their trouble-free performance. They are generally favored over mowing machines, which are frequently broken when operated in orchards.

A type of weed chopper that tapers from one end to the other has been developed recently. The tapering gives a slicing action to the

¹⁶ Growers should purchase only certified seed of these varieties, as distinction cannot be made between reseeding and nonreseeding crimson clover.



Figure 15.—Cover crops or weeds and grass may be cut down with a weed chopper to prepare land for harvest. Operation of the chopper is generally trouble-free and because of this is usually preferred to a mower.

cylinder, which makes it effective in cutting weeds. The implement seems to be excellent for fitting the tung orchard for harvest.

COVER-CROP FERTILIZERS

To grow cover crops successfully, proper soil conditions must be provided and suitable fertilizers applied. As pointed out on page 8, most soils in the tung-producing area are too acid for the best growth of cover crops, especially legumes.

For satisfactory stands of cover crops an application of 500 pounds per acre of dolomitic limestone should be made annually on most soils until the pH, or acidity measurement, of the soil reaches 6.0 to 6.5. After that the quantity of dolomitic limestone to be applied should be reduced. Dolomitic limestone supplies calcium and magnesium, which are required by both the cover crops and the tung trees.

Cover crops, especially legumes, will make little growth unless they are liberally fertilized with phosphorus.

If basic slag can be obtained it should be applied at the rate of 300 to 500 pounds per acre at the time of seeding the cover crop. When basic slag is applied it is not necessary or desirable to apply the dolomitic limestone unless the soil is very acid, because the slag contains considerable calcium and a smaller amount of magnesium. Basic slag is not toxic to the seed or to the inoculum on the seed, and therefore may be distributed and worked into the soil at the time of cover-crop seeding.

If basic slag is not available, 200 to 250 pounds of 20 percent superphosphate will as a rule produce excellent cover-crop growth. A good

rule to follow is to apply the superphosphate and lime and work them into the soil 1 to 2 weeks before seeding the cover crop.

FERTILIZER REQUIREMENTS

The height of head and the number and distribution of the primary lateral branches of a tung tree are determined during the first year in the orchard. Good growth of a tung tree is especially important the first 4 to 6 years after it is planted in the orchard in order that a strong framework may be formed and a large bearing surface attained as quickly as possible.

Mature trees produce fruits only from the terminal buds of shoots of the preceding growing season. So, for continued good crop production the mature trees must grow moderately vigorously and form a large number of strong shoots each year.

Adequate cultivation and a leguminous cover crop are basic requirements for attaining maximum production, but good culture must be supplemented with proper fertilization. Most soils on which tung is planted are inherently low in fertility.

Of the essential elements obtained by plants from the soil, nitrogen, phosphorus, and potassium are most likely to become deficient. Tung trees require nitrogen in large quantities. Present knowledge indicates that phosphorus is required by the tung tree in small quantities but that the small amount needed is of the utmost importance. Some soils are by nature low in phosphorus and some tend to fix and render unavailable both natural and added phosphorus. Potassium is especially essential for mature trees. (Discussed on pages 31 and 33.)

Approximate average requirements of the essential elements nitrogen, phosphorus, and potassium per tung tree and per acre for 70-, 100-, and 140-tree plantings are given in table 3. The schedules may be modified to fit local conditions. It is often thrifty to purchase each element separately. Nitrogen may be purchased at minimum cost in liquid form as anhydrous ammonia (fig. 16), and phosphorus



Figure 16.—This machine is used to apply liquid fertilizer to tung trees. The liquid is anhydrous ammonia, the tung grower's cheapest source of nitrogen.

may be obtained most cheaply from basic slag. Potash might be purchased most cheaply as muriate (potassium chloride). These fertilizer elements may be applied separately or as complete fertilizer mixtures.¹⁷

TABLE 3.—*Approximate average requirements of the essential elements nitrogen, phosphorus, and potassium per tung tree and per acre*

ALABAMA, FLORIDA, AND GEORGIA ¹

Age of tree (years)	Formula ²	Amount of fertilizer required in—					
		70-tree planting		100-tree planting		140-tree planting	
		Per tree	Per acre	Per tree	Per acre	Per tree	Per acre
	Ratio	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds
Newly planted	6-6- 6	1	70	1	100	1	140
1	6-6- 6	2	140	2	200	2	280
2	10-5-10	3	210	3	300	3	420
3	10-5-10	4	280	4	400	4	560
4	10-5-10	6	420	5	500	5	700
5	10-5-12	8	560	6	600	6	840
6	10-5-12	12	840	8	800	7½	1, 050
7	10-5-12	14	980	10	1, 000	9	³ 1, 260
8	10-5-12	16	1, 120	12½ ³	1, 250	9	1, 260
9	10-5-12	18	³ 1, 260	12½	1, 250	9	1, 260

LOUISIANA, MISSISSIPPI, AND TEXAS

Newly planted	5-10- 5	1	70	1	100	1	140
1	8- 8- 4	1½	105	1½	150	1½	210
2	8- 8- 4	2	140	2	200	2	280
3	12- 6- 9	3	210	3	300	3	420
4	12- 6- 9	4	280	4	400	4	560
5	12- 6- 9	6	420	5	500	5	700
6	12- 6- 9	8	560	7	700	6½	910
7	10- 5-10	11	770	9½	950	7½	⁴ 1, 050
8	10- 5-10	13	910	10½ ⁴	1, 050	7½	1, 050
9	10- 5-10	15	⁴ 1, 050	10½	1, 050	7½	1, 050

¹ Additional requirements for this area: On light soils, magnesium (calculated as magnesium oxide (MgO)) and applied at half the rate for potash. For young trees, 2 to 4 ounces of zinc sulfate per tree annually for the first 3 or 4 years.

² Ratios stated in pounds (percent) of nitrogen, phosphoric acid (calculated as phosphoric pentoxide (P₂O₅)), and potash (calculated as potassium oxide (K₂O)), contained in 100 pounds of mixed fertilizer. Difference between ratio totals and 100 made up by additional fertilizer elements or filler. Formulas, amounts, and fertilizer sources may be varied so long as equivalent amounts of the basic nutrients are supplied.

³ The amount per tree remains constant for this area after a maximum of 1,250 to 1,260 pounds per acre is attained.

⁴ The amount per tree remains constant for this area after a maximum of 1,050 pounds per acre is attained.

¹⁷ A helpful publication is U. S. Department of Agriculture Farmers' Bulletin 2007, *Mixing Fertilizers on the Farm*, available from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., for 5 cents.

On soils of the western part of the Tung Belt, nitrogen and phosphorus are essential for the good growth of newly planted tung trees. Potassium applications are not consistently beneficial. A mixed fertilizer containing nitrogen at the rate of 0.06 to 0.08 pound per tree, phosphorus at the rate of 0.08 to 0.16 pound of phosphoric acid per tree, and potassium at the rate of 0.04 pound of potash per tree gives consistently good results.

Of the ready-mixed commercial fertilizers now available, 1 pound of 5-10-5 fertilizer per tree will supply approximately the best amounts of these three elements needed under average conditions in the Louisiana-Mississippi-Texas area.

In recent years symptoms of deficiency of zinc have occurred frequently in newly planted orchards, especially on land that previously had been used for growing general farm crops. Zinc-deficient tung trees make uneven growth, the leaves are sickle-shaped, and the areas between the veins lose their green color (fig. 17). When these symptoms are observed 2 ounces of zinc sulfate per tree should be applied promptly.

As the trees become older, the ratio of nitrogen in the formula should be increased. The response to phosphorus usually is less marked after the first year, so there should be a decrease in proportion of phosphoric acid. Thus, 1.5 pounds of 8-8-4 fertilizer might be required per tree at 1 year of age and 2 pounds of the same mixture at 2 years of age. If not available on the market a fertilizer of approximately that composition may be made by mixing one bag of ammonium nitrate with nine bags of 5-10-5 fertilizer.

When tung trees begin to fruit moderately to heavily, the length of shoot growth declines. More nitrogen is then needed to maintain good shoot growth and fruiting. It is suggested that, beginning when the trees are 4 years of age, nitrogen be applied at the rate of approximately 0.12 to 0.16 pound per tree per year of age.

After the second or third year in the orchard tung trees evidently can obtain a high proportion of the phosphorus needed from phosphorus occurring naturally in the soil and from phosphorus applied to cover crops. The rate of application then can be 0.5 pound of phosphoric acid for each pound of nitrogen applied.

Potassium is used in large quantities by the bearing tree for growth and fruiting (fig. 18). This element plays a major role in developing and maintaining a high oil content of the fruit. When commercial production starts at 3 to 4 years of age, 0.75 pound of potash is needed for each pound of nitrogen until such time as production reaches approximately 1 ton of fruit per acre. High yields drain the potash supply because a ton of fruit may remove from 30 to 35 pounds of potash from the orchard. To supply the potassium needed for the fruit produced and for growth of trees producing at the rate of 1 ton or more per acre, 1 pound of potash should be applied for each pound of nitrogen used.

The amount of fertilizer required, either per tree or per acre, tends to be in proportion to the bearing surface. In closely planted orchards crowding will tend to retard the growth of the trees after the third or fourth season as compared with trees more widely spaced. However, during the early years of production, total bearing surface per acre will increase more rapidly with the closely spaced trees. Some orchards



Figure 17.—This young tung tree shows uneven growth caused by zinc deficiency. The leaves tend to be sickle-shaped, and the areas between the veins have lost their green color.

are still planted at the rate of 70 trees per acre, but most new plantings are more closely spaced. Therefore, fertilizer requirements for plantings of 70, 100, and 140 trees per acre are given in table 3. The maximum bearing surface per acre will eventually be about the same, whatever the number of trees. When the maximum is reached, the fertilizer requirement will level off at approximately 1,050 pounds per acre in the western Tung Belt area. This stage is attained most quickly in the closely planted orchards.



Figure 18.—When tung trees are deficient in potassium the leaves scorch and fall but the fruit hangs on.

FOR ALABAMA, FLORIDA, AND GEORGIA

As soils in the eastern part of the Tung Belt are generally higher in phosphorus and lower in potassium and zinc than soils in the Louisiana-Mississippi-Texas area, the ratio of phosphorus should be reduced and the ratio of potassium and of zinc should be increased as compared with the formula recommended for young trees in the western part of the Tung Belt. Also, tung soils of the eastern tung-growing States are in general less fertile and less capable of retaining fertilizers than those in the western part of the belt. Larger amounts per tree and per acre are recommended for the eastern area than for Louisiana, Mississippi, and Texas.

One pound of 6-6-6 fertilizer plus 3 ounces of commercial zinc sulfate per tree should result in good growth on newly planted trees in most locations in Alabama, Florida, and Georgia. In addition, on light soils in this area it is well to include magnesium in the mixture. Manganese and copper may also be needed. When the tung tree is 1 year of age, the amount of each nutrient in the fertilizer may be doubled, but at 2 years of age the ratios should be modified to provide relatively less phosphorus and more nitrogen and potassium. Three pounds of a 10-5-10 mixture supplemented with magnesium, zinc, and other elements as needed would be satisfactory. This formula, which calls for 0.5 pound of phosphoric acid and 1 pound of potash for each pound of nitrogen, should be used until the trees come into heavy bearing at perhaps 5 or 6 years of age. On soils of the eastern part of the Tung Belt, it is recommended that heavy-bearing trees receive 1.2 pounds of potash for each pound of nitrogen applied.

As explained in recommendations for the western part of the Tung Belt, closely planted trees will grow somewhat more slowly than those having more space. A smaller quantity of fertilizer is required per tree in close plantings, but the amount required per acre during the early years of production will be larger than for more widely spaced trees. Regardless of the number of trees, the fertilizer requirement per acre in the eastern part of the Tung Belt will level off at about 1,260 pounds of a 10-5-12 mixture, because the total bearing surface will eventually be about the same. Maximum bearing surface per acre will be attained more quickly in the close plantings.

TIME AND METHOD OF APPLICATION

Because the root system of a tung tree is greatly reduced when it is transplanted from the nursery to the orchard, its ability to obtain the necessary fertilizer elements from the soil is also reduced. Therefore, placement and time of application of the fertilizer are important. New shoot growth generally precedes new root growth. As soon as shoot growth is evident, fertilizer should be applied on the soil within a radius of 15 or 16 inches from the tree trunk. The fertilizer should be hoed in, because phosphorus does not readily move downward from the surface of the soil.

In bearing orchards it is best to apply fertilizers at about blossom-time to an area under each tree that corresponds to the spread of the branches. However, excellent results are produced when nitrogen is applied much earlier, as in January. As has been indicated, there is quite a bit of latitude in the choice of date of phosphorus application. This element may be applied in June to a summer cover crop or native vegetation, or in the fall to a winter cover crop. When the cover crop disintegrates, the phosphorus it has absorbed is released to the trees. The potassium may be applied to the trees in early spring with the nitrogen; or to the cover crop at planting time, either in early summer or in the fall.

INSECTS AND DISEASES

The tung tree has been relatively free from insects and diseases in the United States. Grasshoppers sometimes eat holes in the leaves, and a few instances are known in which the bollworm (*Heliothis armigera*) has attacked the young fruit. The larvae of the coffee bean weevil (*Araecerus fasciculatus*) sometimes infest the hulls of the nearly mature fruit, but without serious ill effects. Probably the most serious insect pests are the cottony-cushion scale (*Icerya purchasi*) and the oleander scale (*Aspidiotus hederae*).

Although infestations of the cottony-cushion scale occasionally cause the tung growers much concern, the insect is readily controlled by the vedalia beetle (*Rodolia cardinalis*), which feeds on the scales. The beetles usually appear naturally when food is abundant. If they do not appear, they can be purchased from commercial sources.

The oleander scale is also attacked by some insects, but if infestation is severe it may be necessary to spray in late winter with an oil emulsion at the rate of 2 to 3 gallons of concentrate in water to make 100 gallons of spray material. If the application is thorough, practically complete control is effected without injury to the trees.

One of the relatively serious parasitic diseases of tung is thread blight (caused by *Corticium stevensii*). This surface parasite kills

the leaves, which then hang suspended by the threads of fungus. The disease overwinters as chestnut-brown, beadlike sclerotia (fungus sacs) on the twigs. If the infection is not extensive, the affected branches may be pruned out and burned. The disease may be readily controlled with bordeaux mixture applied once a year, preferably just after the fungus threads start to grow out from the overwintering sclerotia. In seriously infected orchards, where no control is practiced, yields are reduced by about 20 to 30 percent.

Nut rot (caused by *Botryosphaeria ribis*) has been known in the southern United States for at least 15 years. Fruits infected early in the season tend to drop prematurely and contain little or no oil. If infected late in the fall the entire fruit may mummify and hang on the tree. These late-infected fruits are harvested with difficulty but are normal or nearly normal in oil content. No feasible control is known.

Black rot canker (caused by *Physalospora rhodina*) occurs principally on young trees, which may be killed back almost to the soil level. Later, new shoots develop just below the canker. Sometimes only a few of the upper branches are affected. The dead branches become ash gray in color, with numerous black perithecia (fruiting bodies) scattered over the surface. Pruning out and burning of diseased branches is advisable.

Clitocybe root rot (caused by *Clitocybe tabescens*), which occurs on native oak and other forest trees, may attack tung planted in newly cleared land. The infected area usually spreads slowly for several seasons but in the final stages death comes quickly when the tree is in full leaf. The bark will be found to be dead at and just below the ground line and a white mat of fungus threads may be seen between the bark and the wood. The disease characteristically kills a tree here and another there, but never destroys an orchard. No feasible control is known, but it is inadvisable to replant in the same spot where a tree has been killed by this disease.

Tung is also subject to a bacterial leaf spot (caused by *Pseudomonas aleuritidis*), to a disease known as alcoholic flux, and to a disease known as web blight (caused by the fungus *Corticium microsclerotia*) that sometimes attacks young trees in the nursery. None of these diseases are common or likely to cause serious loss.

HARVESTING

Tung fruits mature and drop to the ground in late September to early November. At the time the fruits fall, they contain as much as 60 percent moisture by weight. They should be left on the ground 3 or 4 weeks until the hulls are dead and dry and the moisture content of the whole fruit has dropped to about 30 percent. The fruits do not deteriorate on the ground until germination starts in the spring, but if they are gathered before the leaves fall a great deal of expense and trouble is saved.

The fruits are nearly always gathered by hand into bushel baskets. Various types of baskets may be used, although openwork wire bushel baskets are favored. The price given pickers per bushel is adjusted according to conditions in the orchard. In an orchard free from grass, weeds, and briars, where the trees are producing from 1½ to 2 tons per acre, an average picker can gather 60 to 80 bushels per day. On the other hand, if the orchard is bearing only ½ ton to the acre

and the fruit is hidden among weeds and briars, a picker will find it difficult to gather 30 to 40 bushels per day.

To encourage workers to gather fruit all through the season, many growers have the crop gathered from the poorer sections of their orchards first. The pickers generally work in crews of 15 to 20, with a foreman for each crew.

The harvest usually has to begin before the last fruits have fallen. It is difficult if not impossible to shake all the remaining fruits off the trees so that harvesting can be completed with one gathering. Long, tough stalks or stems permit the tung fruits to swing rather than to jar loose; therefore, it is almost always necessary to make a second picking, or "scrapping." The rate paid for scrapping is generally two or three times more than for the first picking. Foremen may find that some workers are inclined to leave a good deal of fruit under the trees during the first harvest so that they may earn more during the scrapping operation.

As gathered from the ground, tung fruit is seldom dry enough for delivery to the mill. It is usually sacked, placed in trees, and allowed to dry for 2 or 3 weeks.

However, most mills are equipped with driers that make possible the processing of whole fruit that has 30 to 40 percent moisture content. The kernels of these fruits contain only about 15 or 20 percent moisture because they absorb moisture to a much less extent than the shells and hulls. Therefore, the grower may feel that it would be advantageous to deliver the crop to the mill as soon as the fruits are gathered.

Wet fruit will contain a low percentage of oil. If the grower is to be paid on the basis of oil delivered and the fruit is delivered wet, the grower will receive less per ton than he would if it were dry. Also, if wet fruit is milled for the grower's account, he will have to pay for milling a larger number of tons than if dry fruit is delivered.

The changes in weight and in percentage oil content when any given lot of tung fruit gains or loses moisture are of vital importance to tung growers because they affect the cost (and sometimes the guaranteed recovery of oil) in custom milling. The method of computing the relative weights at different moisture contents is readily understood if one keeps in mind two basic principles:

(1) The weight of dry matter in any given lot of fruit cannot change, no matter how much moisture is gained or lost. (Weight of oil is included in weight of dry matter.)

(2) Whatever the percentage of moisture, the remainder of 100 percent is dry matter. Thus if the moisture is 25 percent, the dry matter is 75 percent.

For example, a ton of fruit containing 40 percent moisture will have 60 percent dry matter, which is 1,200 pounds. If the lot should dry down to 30 percent moisture, it will still have 1,200 pounds of dry matter, which will then constitute 70 percent of the total weight. To find the new weight divide the number of pounds of dry matter by the percentage units of dry matter at the new moisture content; then multiply by 100, thus:

$$\frac{1,200 \text{ pounds dry matter}}{70 \text{ percentage units dry matter}} \times 100 = 1,714 \text{ pounds (total weight of the lot at 30 percent moisture)}$$

If the lot had lost moisture down to 15 percent, the 1,200 pounds of dry matter would then constitute 85 percent of the total weight, which would be:

$$\frac{1,200}{85} \times 100 = 1,412 \text{ pounds (total weight of the lot at 15 percent moisture)}$$

The weight of oil, which is part of the dry matter, does not change when moisture is gained or lost. Let us assume that the lot of fruit in the example contained 300 pounds of oil. The percentages of oil corresponding with the different moisture contents are then readily computed. At 40 percent moisture the lot weighed 2,000 pounds, and 300 is 15 percent of 2,000. At 30 percent moisture the lot would weigh 1,714 pounds, and 300 is 17.5 percent of 1,714. At 15 percent moisture the lot would weigh 1,412 pounds, and 300 is 21.2 percent of 1,412.

On a milling contract that guarantees a stated percentage recovery of the total oil, the oil credited to the grower will be the same regardless of moisture content at the time of milling. However, the charge for milling is based on the weight when delivered to the mill. Assuming a charge of \$12.50 a ton for processing, the cost (for the same net credit of oil) would be \$12.50 if milled at 40 percent moisture, \$10.71 if milled at 30 percent moisture, or \$8.83 if milled at 15 percent moisture. Corresponding savings will be made on the cost of hauling from farm to mill.

On some milling contracts the guaranteed recovery is based on a fixed deduction, for example 2.5 percent, from the laboratory determination of oil content. In that case if the fruit were delivered at 40 percent moisture the guarantee would be 12.5 percent (15.0-2.5) of the 2,000 pounds, which is 250 pounds. If the fruit were delivered at 30 percent moisture the grower would be credited with 15.0 percent (17.5-2.5) of 1,714 pounds, which is 257 pounds. If the fruit were delivered to the mill at 15 percent moisture the grower would be credited with 18.7 percent (21.2-2.5) of 1,412 pounds, which is 264 pounds. On a contract of this type, the grower would not only lower the cost of hauling and processing, but would also gain in oil credited by delivering the fruit as dry as possible.

If the grower decides to dry the fruit before delivery to the mill or if the mill cannot accept delivery as fast as the crop is harvested, the most common practice is to empty the baskets into "croaker" (burlap) sacks and hang them in the trees (fig. 19). Fruit handled in this manner will not heat or spoil even during a long period of rainy winter weather. However, both sacks and labor are expensive. For an average crew of 15 to 20 pickers, 3 men will be required to fill the sacks, tie or sew them shut, and put them in the trees. After 2 or 3 weeks of dry weather, the sacks are removed and "ramped out," that is, loaded on wagons or tractor-drawn trailers and carried to a main road where they are stacked in piles for pickup and transport by trucks to the mill.

Instead of hanging sacks of tung fruit in the trees to dry, many growers place the fruit in field storage sheds. A disadvantage of storage is that deep layers of fruit dry slowly and when the fruit has a moisture content of 25 percent or more it is likely to heat and spoil.

To provide good ventilation, the sheds are constructed simply with open spaces in the bottom and sides (fig. 20). They are built wider



Figure 19.—To reduce the moisture content, newly gathered tung fruits are usually sacked, placed in the trees, and allowed to dry for 2 or 3 weeks.



Figure 20.—Many growers store tung fruit in large sheds like this to dry. Fruit that is stored too wet is likely to heat even in this well-ventilated structure, and therefore requires close attention to prevent spoilage.

apart at the top than at the bottom, like old-fashioned corncribs, and an overhanging roof is generally provided to keep rain from coming into partially filled bins. The floors are often constructed of 1-inch-mesh poultry netting or 1/2-inch-mesh hardware cloth laid over the floor joists, with sides of the same material attached to studs spaced on 24-inch centers.

Growers who wish to store the crop in sheds have the pickers dump their baskets into tractor-drawn trailers. The pickers are credited with each basket delivered. The tractors then haul the trailers to the storage shed where the fruit is carried up in elevators and distributed by conveyors to different bins. Wet fruit must be distributed in thin layers over a number of different bins and must have time to dry out before more is added. This requires a large storage shed with many bins; and good judgment and close attention are required to avert fruit spoilage.

Present methods of harvesting, handling, and storing the tung crop are costly and not entirely satisfactory. It is believed that improved methods will be worked out in the near future and that costs will be reduced.

The hulling of fruit in the orchard is one objective. If this were possible, only the hulled nuts, which constitute half the weight, one-third the volume, and one-quarter the moisture of the whole fruit, would then have to be dried and carried to the oil mill or to storage. Also, dry hulls often contain as much as 3 percent potash. Hulls now carried away in every ton of whole tung fruit could provide potassium equivalent to 60 to 70 pounds of 50 percent muriate of potash for the orchard.

In tests with experimental hullers, some of the nut shells crack and the exposed kernels soon deteriorate. Hulled nuts either must be milled within 24 to 48 hours or be dried quickly before being placed in storage.

Engineers of the United States Department of Agriculture are working on these problems and also on the development of a machine for picking up the fruits from the ground. Harvesting machines that do quite good work have already been developed by the Department engineers and by industry.

YIELDS, COSTS, AND RETURNS

The average yield of tung orchards in the southern United States is about one-half ton of whole fruit per acre per year. Most of the present bearing tung orchards were planted before much was known about the soil requirements of the tree or its cultural needs. Also, the only planting stock available consisted of unselected seedling trees, which range widely in productivity. Some of these trees are practically barren.

Nevertheless, orchards of such seedlings, planted on good soil and adequately cared for, often yield 2 tons per acre per year over a period of years and individual crops averaging 3 tons per acre or more have been harvested in fairly extensive orchards.

Far greater yields than the present average may be expected from orchards planted now, if growers will follow these recommendations: Select orchard soil carefully, plant only trees of available budded varieties and seedlings of progeny-tested varieties that are best suited

to the area in which they are to be grown, and give the orchard adequate culture and fertilization.

A small orchard of the La Crosse variety planted in 1941 on the Mississippi Experimental Tung Farm yielded 0.74, 1.70, 2.17, 3.21, and 2.26 tons of whole fruit per acre at 15 percent moisture content in 1946, 1947, 1948, 1949, and 1950, respectively. These yields were obtained from only 62 trees per acre, which have not yet attained full size. Higher yields are to be expected in the future.

The orchard is on Savannah very fine sandy loam soil, which is considered only a second-rate tung soil, and has received good but not exceptional care.

This orchard is cultivated four times during a season. The winter legume cover crop is turned under when it is still green and succulent by using a disk tiller next to the tree rows and working out the middles between the rows with a tandem disk. Between then and the last of June, the whole area is cultivated twice with a 12-foot spring-tooth harrow. During late summer about 5 man-hours per acre are used in hand hoeing, principally to remove volunteer tung trees. Native growth that comes up during the rainy summer months is turned under and the land is prepared for harvest by cultivating the whole area with a tandem disk as late as possible before the fruits start to drop.

In October, 600 pounds of basic slag per acre is applied just before seeding a winter cover crop. In March about 225 pounds of ammonium nitrate and 170 pounds of 50 percent muriate of potash are applied per acre, directly beneath the branches of the trees. As of 1949 these operations cost \$30 to \$35 per acre annually, depending on prices paid for materials and the efficiency with which the work was carried out. These costs do not include interest, taxes, and other items of overhead expense.

Costs of harvesting and marketing vary, depending upon the yield and state of culture of the orchard. Costs for harvesting and marketing the whole crop for the 1949 season ranged from \$10 to \$25 per ton.

The price the grower may expect to receive for his fruit will be based on the current and expected price for oil. As mentioned earlier in this bulletin, the price of oil tends to fluctuate widely. Prices ranged from 19.5 to 26.5 cents and from 24 to 36 cents a pound during the calendar years of 1949 and 1950, respectively, for domestic oil in tank cars and at the mill.

The National Agricultural Act of 1949 added tung nuts to the list of nonbasic agricultural commodities on which price support is mandatory. The price-support level is between 60 and 90 percent of parity and for a 5-year period. The crop of 1949 (marketing year 1949-50) was the first one supported—at 60 percent of parity, or \$60 per ton of fruit containing 17.5 percent oil. The 1950 crop also was supported at 60 percent of parity as of November 1, 1950. The parity price of tung nuts on that date was \$105 per ton, and the average support price was \$63 per ton. The price is adjusted 36 cents for each variation of one-tenth percent oil content. Grower-owned tung oil was supported at 25.1 cents per pound.

The grower may sell his crop outright to a miller or he may have it processed on a custom basis, either selling his own oil or pooling it with that of other growers. The charges for milling the crops of

1949 and 1950 averaged about \$12.50 per ton of whole fruit, the mill retaining the byproducts.

As a rule about 86 percent of the oil can be extracted from the fruit. A ton of whole fruit containing 17.5 percent oil will produce an average of 300 pounds of salable oil. At 25.1 cents per pound the grower would receive \$62.80 for the 300 pounds of oil, after average milling costs are deducted. If the oil were sold for 36 cents a pound, the grower's return after milling costs would be \$95.50. However, if the fruit averaged 20 percent oil content, the grower's return on the basis of 36-cent oil would be \$111.34 after milling costs. If this same fruit were sold outright to a miller, the grower would receive a base price of at least \$63.00, plus \$9.00 for the 2.5 percent oil content above the 17.5-percent base, or a total of \$72.00 per ton. Certain of the best new varieties of tung produce fruit that averages nearly 23 percent oil at 15 percent moisture content.

There will be little profit from a tung orchard with average yields of 1 ton or less per acre of fruit containing 17.5 percent oil when the price paid for oil is low. High average yields, 1.5 to 2 tons per acre, of fruit with high oil content should be the objective of every tung grower.

As stated earlier, a farmer already living on the land can start a tung orchard with a very small cash outlay. Tung growing fits well into diversified farming; and equipment requirements are simple for a few trees, enlarging according to the extent of production. Low-priced land and labor are necessary for a successful tung enterprise.

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